ELECTROCOAGULATION FOR SUSPENDED SOLID REMOVAL IN DOMESTIC WASTEWATER TREATMENT

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ABSTRACT

The treatment of wastewater has become an absolute necessity. Innovative, cheap and effective methods of purifying and cleaning wastewater before discharging into any other water systems are needed. A wide range of wastewater treatment techniques are known which include biological processes and physicochemical processes. A host of promising techniques based on electrochemical technology are being developed and existing ones are improved that require less chemical additions. The present study was conducted to investigate the applicability of the electrocoagulation technique for the treatment of domestic wastewater at the UTM Oxidation Pond effluent as a case study. The combination effects of current, pH and treatment time to the efficiency of the electrocoagulation process for the removal of suspended solids from the domestic wastewater showed that only current(C) and treatment time (t) have correlation with each other. The optimum batch technique operational conditions for the electrocoagulation application to remove suspended solids from domestic wastewater is current value is 0.5A – 0.65A within 46 until 60 minutes treatment time. These optimum conditions have an optimum result with 120 minutes settling time. Meanwhile the optimum conditions for batch technique were applied to the continuous flow method while resulted in between 80-83% efficiencies of suspended solid removal from the wastewater.

ABSTRAK

Rawatan sisa air kumbahan adalah menjadi semakin penting dalam dunia hari ini. Cabaran saintis dan jurutera hari ini adalah untuk menghasilkan kaedah yang inovatif, murah dan efektif di dalam merawat sisa kumbahan air sebelum di salurkan ke sungai.Terdapat banyak kaedah untuk merawat sisa kumbahan air yang merangkumi proses biologi serta gabungan antara proses fizikal dan proses kimia proses. Antara proses rawatan air yang menjanjikan kaedah terbaik adalah kaedah yang berasaskan elektrokoagulasi di mana kaedah ini menggunakan teknologi elektrokimia yang terbukti berkesan dalam merawat sisa kumbahan air dan mengunakan hanya sedikit tambahan bahan kimia. Kajian dalam penulisan ini dikendalikan untuk mencari keberkesanan kaedah elektrokoagulasi di dalam merawat sisa air kumbahan domestik di mana sampel air kumbahan di dapati dari kolam oksidasi Universiti Teknologi Malaysia, Skudai. Di dalam kajian ini, tiga parameter iaitu arus elektrik (C), pH dan masa rawatan (t) digunakan untuk mencari kombinasi parameter yang paling efisien dalam proses elektrokoagulasi untuk menyingkirkan pepejal terampai. Di dalam kajian ini didapati hanya arus elektrik (C) dan masa rawatan (t) yang mempunyai hubungkait diantara satu sama lain. Semasa mengaplikasikan teknik static di dapati nilai optimum untuk arus elektrik ialah 0.5A – 0.65A dan masa rawatan adalah 46 sehingga 60 minit. Nilai optimum ini menunjukkan kadar efsien apabila proses pengenapan pepejal terampai dibiarkan selama 120 minit. Manakala untuk proses arus air terus menerus, nilai kadar efisiensi penyingkiran pepejal terampai adalah diantara 80-83% effisiensi.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Problem

One of the challenging tasks faced by scientists and engineers today is to provide safe and clean water to support healthy human life. But human activities always generate wastewaters which contain various pollutants that create problems to aquatic life and contaminate water resources. Although wastewaters may come from various sources, it is mostly consists of domestic wastewaters (DWWs). Currently, DWW is normally treated by aerated biological methods. For example, the activated sludge, being the most famous biological method of wastewater treatment, produces high quality effluent, i.e.90% biological oxygen demand (BOD) and suspended solids (SS) removal (Metcalf and Eddy, 2003). There are some disadvantages of applying the biological method for wastewater treatment, such as requiring continuous air supply, high operating costs (skilled labor, energy, etc.), sensitivity against shock toxic loads, longer treatment time, and necessary sludge disposal. Other alternative solutions to wastewater treatment problems are still needed and the present laboratory scale studies have been carried out to treat DWW by using electrocoagulation.

From an environmental point of view, the sewage treatment process is still far from being environmentally sustainable. There is an urgent need for the development of a more sustainable treatment process. Some of the possibilities include electrochemical treatment, improvement of the mitigation of toxic pollutants, high-temperature sludge treatment processes, and membrane separation processes (Rulkens, 2006). Electrochemical is a promising treatment method due to its high effectiveness, its lower maintenance cost, less need for labor and rapid achievement of results (Feng et al., 2003). The electrocoagulation-flotation method for DWW treatment has a greater ability for the removal of COD and SS from effluents in comparison with treatment by conventional coagulation. Jiang et al., 2002have identified that electrocoagulation (EC) is the most appropriate treatment alternative for DDW and it is shown to be one of the best methods for the wastewater. Because of reusing the wastewater has become an absolute necessity, there is an urgent need to develop an inventive, more effective and low-cost technique for the treatment of wastewater (Feng et al., 2003).

A successful application of electrocoagulation (EC) technique for the removal of suspended solids from wastewater would address the environmental needs of reduction in the operational costs and potential saving in processing unit. Among different physical and chemical methods of water and wastewater treatments, method offers a special attraction due to its ecologically friendly, safety, simplicity and lower operating costs (Sohaili.J, et.al., 2004).

The physical and chemical properties of water-dispersed systems can be altered by implicating a certain influence of magnetic field on the structure of water and aqueous solutions. Magnetic field can improve technological characteristics of the water such as better salt solubility, kinetic changes in salt crystallization and accelerated colloidal coagulation. (M. F. Ni'am, et, al. 2007) Magnetic field is

known to create the asymmetry of hydrated shells due to its effect on water molecules situated around the charged particles (colloid). Exposure to magnetic field would lead to higher electro-kinetic movement among the colloid. This definitely will help in attributing to a higher probability of attracting particles to cloak with one another. The theory of magnetic field impact on technological processes for water treatment falls into two main categories; crystallization at magnetic water preparation and impurity coagulation in water systems (Fadil Othman et.al., 2003).

1.2 Problem Statements

In anticipation of shrinking fresh water resources and increasing safe and clean water demand in the future, treatment of domestic wastewater (DDW) has become a necessity. Electrocoagulation technology provides an alternative to the conventional water and wastewater treatment that requires no chemical additions. Magnetic treatments for water and wastewater, on the other hand, are especially attractive due to their safety, ecological purity, environmental friendly and simplicity.

The primary concern of this research is to investigate the feasibility of magnetic and electrocoagulation technology in assisting sedimentation of suspended solids and to better understand the mechanism and impact of both applications in domestic wastewater treatment. Thus this will help us in innovating and developing a new wastewater treatment process by utilizing magnetic and electrocoagulation technologies to convert domestic wastewater into safe and clean water that is increasingly in demand.

1.3 Objectives of the Study

The present study was carried out to investigate the applicability of the EC technique for the treatment of domestic wastewater. The objectives of the study are:

i. To investigate the combined effects of current, pH and treatment time to the efficiency of the EC process for the removal of suspended solids from the domestic wastewater by using a batch technique;
ii. To determine the optimum batch technique operational conditions for the EC application to remove suspended solids from domestic wastewater;
iii. To apply the batch technique optimum conditions for the removal of suspended solids from the domestic wastewater by using continuous flow technique.

1.4 Scope of the Study

To achieve the above objectives the effect of magnetic field and EC on the removal of SS (Suspended Solid) due to three variables: DC Current (C), treatment time (t), and pH value (pH) were investigated. These parameters could be expressed as:

$$\Delta SS = f(C, t, pH)$$

The concept of this model is to identify if the combination of magnetic field and EC would have an effect on the process of suspended solid removal and settling in wastewater. This research is mainly focused on the capability of both technologies to removal and increase the sedimentation of suspended solid through static and continuous flow processing methods.

1.5 Significance of the Research

The significance of this research is to provide an alternative method for the treatment of wastewater using a combined magnetic field and electrocoagulation process. Application of magnetic field and electrocoagulation method is more environmentally friendly and could contribute to the future sustainable safe and clean water supply for healthy human living.

1.6 Definition of Terms

Coagulation **:** a phenomenon in which the charged particles in colloidal suspension are neutralized by mutual collision with counter ions and are agglomerated, followed by sedimentation.

Electrocoagulation **:** an electrochemical process that simultaneously removes heavy metals, suspended solids, emulsified organics and many other contaminants from water using electricity instead of expensive chemical reagents.

Electroflotation **:** a simple process that floats pollutants to the surface of a water body by tiny bubbles of hydrogen and oxygen gases generated from water electrolysis.

Electrodeposition **:** the electrochemical mechanism for recovery of heavy metals from wastewater streams. It basically is the cathodes deposition as $M^{n+} + ne \rightarrow M$.

Electrooxidation **:** the electrochemical application in wastewater treatment in combination with other technologies and effective in degrading the refractory pollutants on the surface of a few electrodes.

Magnetic memory **:** the long term effects of which persist of hours or days after water treatment with the magnetic fields/ electromagnetic.

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